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RESEARCH MEMORANDUM

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Abstract

This paper investigates the joint labor supply decision in households in a neo-classical framework. Besides the more traditional explanatory variables like wages, taxes, welfare-benefits and demographic factors, we highlight the importance of habit formation and interdependence of preferences. Habit formation adds a dynamic aspect to the standard neo-classical model. Incorporation of interdependent preferences yields a micro-model that implies different wage elasticities of labor supply for individual households than for aggregates. As such it may account for the often observed inconsistencies between predictions from micro-models and macro-models.

We find that the model with habit formation and preference interdependence produces results different from the standard model without these factors. Since the extended model must be preferred on statistical grounds, we conclude that the standard model may give rise to misleading results.

1. Introduction

The main contribution of this paper is the implementation of habit formation and interdependence of preferences in a neoclassical model of household labor supply. We allow for the fact that individuals may get used to working a certain number of hours per week (habit formation) and that the number of hours they prefer to work may depend on the number of hours other people worked (interdependence of preferences). Habit formation and preference interdependence jointly will often be referred to as preference formation.

The notion that preferences may be endogenous has gained some foothold in the literature on consumer demand equations [cf., e.g., Pollak (1970, 1976), Phlips (1984), Gaertner (1974), Blanciforti and Green (1983), Darrough, Pollak and Wales (1983), Alessie and Kapteyn (1986) and the references given in these papers], but hardly any in the labor supply literature. Empirically, habit formation is usually the only component of preference formation that is being modelled (habit formation may then be either rational or myopic, cf. Muellbauer (1986)). In a few recent working papers, Alessie and Kapteyn (1986) and Kapteyn, Van de Geer, Van de Stadt and Wansbeek (1985) have also incorporated preference interdependence into empirical models of consumption following theoretical notions developed by Gaertner (1974) and Pollak (1976). In the present paper, the framework developed in the two former papers is extended to deal with household labor supply.

The incorporation of preference formation in a neoclassical model is only one step towards a realistic model of labor supply. It would be tempting to start from an extremely simple model of labor supply and to concentrate entirely on preference formation. As a matter of fact, this is the predominant strategy found in the economic literature: one concentrates on one important aspect and ignores other factors as much as possible. There are two problems with this. First, oversimplifying a model introduces misspecification which in general will tend to bias statistical tests meant to investigate whether a certain factor (e.g. habit formation) is important in the explanation of behavior. Secondly, and related to the first point, given the oversimplification of the model, any extension of it will look good, if only because it relaxes the restrictiveness of the simple model.

To avoid such problems at least to some extent, we start out from an already fairly complex neoclassical model of household labor supply developed in earlier work (Kapteyn, Kooreman, Van Soest (1986), to be referred to as KKS from now on) and then add explanatory variables representing preference formation. The draw-back of this approach is of course its complexity. Yet, to arrive eventually at a realistic model of household labor supply, we should aim at one model which integrates as many relevant aspects as possible, rather than aiming at a sequence of models that all highlight one factor and are misspecified otherwise.

In Section 2 the neoclassical model that is used as a starting point is described briefly. We shall refer to this model as the <u>standard model</u> throughout. Next, in Section 3, preference formation is added as an explanatory factor. In Section 4 we describe the sample and the estimation results. Section 5 concludes. Given the fairly complex nature of the standard model, a number of appendices have been added which contain various technical details.

2. The Model Specification

We consider households[1] with at least two adults capable of working in paid jobs. The joint labor supply decision of husbands and wives is described by the following model, due to Hausman and Ruud (1984):

$$\tilde{h}_{mk} = \delta_{mk} + \gamma_m \cdot w_{mk} + \alpha . w_{fk} + \beta_m \cdot \mu_k^*, \qquad (2.1)$$

$$k=1,\ldots,N$$

$$\tilde{h}_{fk} = \delta_{fk} + \gamma_f \cdot w_{fk} + \alpha . w_{mk} + \beta_f \cdot \mu_k^*, \qquad (2.2)$$

$$\mu_k^* = \mu_k + \vartheta + \delta_{mk} \cdot w_{mk} + \delta_{fk} \cdot w_{fk} + \tfrac{1}{2}(\gamma_m \cdot w_{mk}^2 + \gamma_f \cdot w_{fk}^2) + \alpha . w_{mk} \cdot w_{fk} \qquad (2.3)$$

where $\tilde{h}_{mk}$:= number of hours the male partner in household k would like to work per week.

$\tilde{h}_{fk}$:= number of hours the female partner in household k would like to work per week.

w_{mk} and w_{fk} := after tax marginal wage rates of male and female, respectively.

μ_k := (weekly) non-labor income of household k.

N := total number of households in society.

ϑ, δ_{mk}, δ_{fk}, γ_m, γ_f, α, β_f, β_m are parameters.

As these supply equations are quadratic in wages, the system is second order flexible. Given that the parameters in the system satisfy certain restrictions, $\tilde{h}_{mk}$ and $\tilde{h}_{fk}$ can be considered as the results of the maximization of a well-behaved household utility function with male and female leisure and total consumption as arguments. Since this is strictly a model of labor supply, equations (2.1) and (2.2) describe the number of hours the male and female partners would like to work, given the wage rates and non-labor income. We will refer to the number of hours each partner would like to work as preferred hours, whereas the number of hours

1) The words "households" and "families" are used as synonyms. This also applies to the pairs "husband, wife", "male, female" and "man, woman".

actually worked by each partner is referred to as actual hours. The actual hours are generally the result of the interplay of household preferences, institutional constraints, and the demand for labor.

In the survey our data comes from, preferred hours were measured by asking both adult partners the following question:

"Suppose you could freely choose the number of hours you work per week. How many hours would you like to work in your present job, if you could choose them yourself and if you would earn on average the same amount of money per hour as you do at the moment. If you choose fewer hours of work, you choose for less income. And more hours of work means more income. Assume that the number of hours of other members of the household, if any, do not change."

From the wording of this question two things are clear. The respondent should assume a linear budget constraint and he/she should assume that the partner is rationed at her/his actual hours. The latter point implies that the responses should be explained by rationed versions of (2.1)-(2.3). That is, one should compute $\tilde{h}_{mk}$ with $\tilde{h}_{fk}$ rationed at the actual number of hours and *vice versa*. See KKS and Appendix 1. For people without a job, the above question was replaced by a question which asks if the respondent is presently looking for a job. In terms of (2.1)-(2.3) this means for example that if $\tilde{h}_{mk}$ is positive, the male should be looking for a job (given the number of hours actually worked by the female) and that he should not be seeking if $\tilde{h}_{mk} \leq 0$. A complication arises if a presently unemployed person receives unemployment benefits. If this person takes a job, Dutch Law implies that benefits will be reduced. Generally, this introduces non-convexities in the budget constraint. As a result, the person has to compare the utility of working zero hours and receiving a benefit and the utility of working an optimal number of hours without benefits. See KKS and Appendix 1 for details.

3. Preference Formation

The main purpose of this section is to incorporate preference interdependence and habit formation into the neo-classical family labor supply model described in Section 2. In most labor supply models it is assumed that utility functions are constant. As a matter of fact, few economists have analyzed models of interdependent preferences, although the idea that social interactions between individuals are important determinants of one's utility is common in sociology and psychology. Some economic studies are theoretical papers by Becker (1974), Scott (1972), and empirical papers by Tomes (1983) and Kapteyn et.al. (1985). Here we want to allow for the possibility of endogeneous preferences, pretty much along the lines discussed by Pollak (1976) and by Van de Stadt, Kapteyn and Van de Geer (1985).

Habit formation is incorporated into the model by writing certain parameters of the labor supply model as a function of the number of hours worked in the previous period by the male and the female. Preference interdependence is modelled by making the same parameters also dependent upon the number of hours worked by other individuals in the social reference group (a concept to be defined later on), lagged one period.

The choice of the parameters that are made dependent is somewhat arbitrary. We have selected the "translation parameters" (cf. Pollak and Wales (1981)) δ_{mk} and δ_{fk}, mainly for reasons of simplicity. The specification adopted is:

$$\delta_{mk} = \delta_{m0} + \eta_{mm} \sum_{\ell \in P_m} v_{k\ell}^{mm} h_{m\ell}(-1) + \eta_{mf} \sum_{\ell \in P_f} v_{k\ell}^{mf} h_{f\ell}(-1) \qquad (3.1)$$

$$k=1,\ldots,N$$

$$\delta_{fk} = \delta_{f0} + \eta_{ff} \sum_{\ell \in P_f} v_{k\ell}^{ff} h_{f\ell}(-1) + \eta_{fm} \sum_{\ell \in P_m} v_{k\ell}^{fm} h_{m\ell}(-1) \qquad (3.2)$$

where

P_m := the set of all adult males in society

P_f := the set of all adult females in society

$h_{mk}(-1)$:= lagged value of actual hours worked by the male in household k.

$h_{fk}(-1)$:= lagged value of actual hours worked by the female in household k.

$\delta_{m0}, \delta_{f0}, \eta_{mm}, \eta_{mf}, \eta_{ff}, \eta_{fm}$ are parameters,

$0 \le \eta_{mm} + \eta_{mf}, \eta_{ff} + \eta_{fm} \le 1$

$v_{k\ell}^{mm}, v_{k\ell}^{mf}, v_{k\ell}^{ff}, v_{k\ell}^{fm} \ge 0$, for all k, ℓ,

$\sum_{\ell \in P_m} v_{k\ell}^{mm} = 1, \sum_{\ell \in P_f} v_{k\ell}^{mf} = 1, \sum_{\ell \in P_f} v_{k\ell}^{ff} = 1, \sum_{\ell \in P_m} v_{k\ell}^{fm} = 1$, for all k

Notice that it is assumed that the male (female) parameter δ_{mk} (δ_{fk}) not only depends on male (female) hours but also on female (male) hours. In other words, men and women refer both to individuals of their own sex and to individuals of the other sex.

The $v_{k\ell}$'s are called <u>reference weights</u>. For example $v_{k\ell}^{mf}$ represents the importance attached by the male in family k to labor supply behavior of the female in family ℓ. If, for instance, $v_{k\ell}^{mf} = 0$ the female in family ℓ does not belong to the reference group of the male in family k, if $v_{k\ell}^{mf} \ne 0$ she does. Similar interpretations can be given to $v_{k\ell}^{mm}$, $v_{k\ell}^{fm}$ and $v_{k\ell}^{ff}$.

The parameters $\eta_{..}$ measure the importance of preference formation. For example, η_{mf} represents the extent to which the preference parameter δ_{mk} is influenced by the labor supply behavior of females in the reference group of the male in family k.

By inserting (3.1) and (3.2) into (2.1) - (2.3) we obtain a model which relates observables to observables, but with far too many parameters to be estimated. To reduce this huge number of parameters, a number of additional assumptions will be made.

First of all it is assumed that v_{kk}^{mm} and v_{kk}^{ff} do not vary with k, say $v_{kk}^{mm} = \zeta_m$ and $v_{kk}^{ff} = \zeta_f$. This means that the relative influence of habit formation is the same across households. Since $\sum_{\substack{\ell \in P_m \\ \ell \neq k}} v_{k\ell}^{mm} = 1-\zeta_m$ and $\sum_{\substack{\ell \in P_f \\ \ell \neq k}} v_{k\ell}^{ff} = 1-\zeta_f$, the relative influence of preference interdependence is then also the same across households. The larger ζ_m (or ζ_f) the more important habit formation is relative to preference interdependence.

Next we introduce new parameters $q_{k\ell}^{mm}$ defined by

$$
\begin{aligned}
q_{k\ell}^{mm} &:= v_{k\ell}^{mm}/(1-\zeta_m) \quad && k \neq \ell \\
&:= 0 && k = \ell.
\end{aligned}
$$

Obviously,

$$q_{k\ell}^{mm} \geq 0 \text{ for all } k, \ell, \sum_{\ell \in P_m} q_{k\ell}^{mm} = 1 \text{ for all } k.$$

Similarly, we define $q_{k\ell}^{ff} := v_{k\ell}^{ff}/(1-\zeta_f)$ for $k \neq \ell$ and zero otherwise. For notational simplicity we also replace $v_{k\ell}^{mf}$ and $v_{k\ell}^{fm}$ by $q_{k\ell}^{mf}$ and $q_{k\ell}^{fm}$ respectively.

Also the parameters $q_{k\ell}$ wil be called "reference weights". We refer to the set of females for which $q_{k\ell}^{mf} > 0$ as the <u>social reference group</u> of the male in family k. Define

$$\hat{h}_{ijk} := \sum_{\ell \in P_j} q_{k\ell}^{ij} h_{j\ell} \qquad i,j = m,f.$$

The quantities $\hat{h}_{..k}$ are reference group means of working hours. For example, the quantity $\hat{h}_{mfk}$ is the mean of female hours in the reference group of the male in family k. This makes it possible to rewrite (3.1) and (3.2) as:

$$\delta_{mk} = \delta_{m0} + \eta_{mm}[\zeta_m . h_{mk}(-1) + (1-\zeta_m).\hat{h}_{mmk}(-1)] + \eta_{mf}[\hat{h}_{mfk}(-1)] \tag{3.3}$$

$$\delta_{fk} = \delta_{f0} + \eta_{ff}[\zeta_f . h_{fk}(-1) + (1-\zeta_f).\hat{h}_{ffk}(-1)] + \eta_{fm}[\hat{h}_{fmk}(-1)] \tag{3.4}$$

with $0 \le \zeta_m, \zeta_f \le 1$
The second terms in both equations represent habit formation and the last terms represent interdependence of preferences.

Next we consider $\hat{h}_{ijk}$ in somewhat more detail. It seems reasonable to suppose that an individual will primarily assign positive reference weights to people whom he or she knows personally. Within the family we distinguish two channels through which one can get to know other people: the first channel is that one meets someone directly; the second channel is that one meets someone through his (or her) partner. To formalize this idea, let us take $\hat{h}_{mmk}$ (that is the mean of male hours in the reference group of the husband in family k) and rewrite it:

$$\hat{h}_{mmk} = \sum_{\ell \in P_m} q^{mm}_{k\ell}\, h_{m\ell} = \sum_{\ell \in S_{mm}} q^{mm}_{k\ell}\, h_{m\ell} + \sum_{\ell \in S_{fm}} q^{mm}_{k\ell}\, h_{m\ell}, \tag{3.5}$$

where S_{mm} is the set of males that the husband in family k has met directly and S_{fm} is the set of males he has met through his wife (males whom neither of the spouses have met are assumed to receive a reference weight equal to zero; thus they can be assigned arbitrarily to either of the two sets without loss of generality).

Let λ^k_{mm} be the total reference weight assigned to the males in S_{mm}, i.e.

$$\lambda^k_{mm} := \sum_{\ell \in S_{mm}} q^{mm}_{k\ell}, \tag{3.6}$$

so that the total weight assigned to males in S_{fm} equals $1-\lambda^k_{mm}$. We assume that λ^k_{mm} is a drawing from a distribution with mean λ_{mm}, i.e.

$$\lambda^k_{mm} = \lambda_{mm} + \zeta^k_{mm}, \tag{3.6}$$

where $E\left[\zeta^{k}_{mm}/\lambda_{mm}\right] = 0$. Next define $r^{mm}_{k\ell} := q^{mm}_{k\ell}/\lambda_{mm}$ and $s^{mm}_{k\ell} := q^{mm}_{k\ell}/(1-\lambda_{mm})$. As a result (3.5) can be rewritten as

$$\hat{h}_{mmk} = \lambda_{mm} \sum_{\ell \in S_{mm}} r^{mm}_{k\ell}\, h_{m\ell} + (1-\lambda_{mm}) \sum_{\ell \in S_{fm}} s^{mm}_{k\ell}\, h_{m\ell} \tag{3.7}$$

Note that the $r^{mm}_{k\ell}$ and $s^{mm}_{k\ell}$ are non-negative and "on average" they add up to one, i.e. $E\left[\sum_{\ell \in S_{mm}} r^{mm}_{k\ell} | \lambda_{mm}\right] = E\left[\sum_{\ell \in S_{fm}} s^{mm}_{k\ell} | \lambda_{mm}\right] = 1$. We will also denote the $r^{mm}_{k\ell}$ and $s^{mm}_{k\ell}$ as "reference weights". Expressions analogous to (3.7) can be obtained for the other $\hat{h}_{ijk}$, $i,j = m,f$.

The development so far can be represented by a simple diagram. See Fig. 1, which represents the way in which the reference group of the male in family k is partitioned according to the assumptions above. To the left are verbal indications of the various groups of people distinguished. To the right are the weights they receive in the equation for δ_{mk} (3.3).

The final step towards an estimable model is to make assumptions on the distribution of reference weights within each of the elements of the partition in Fig. 1. Here we closely follow Van de Stadt, Kapteyn, Van de Geer (1985), who make three assumptions which lead to the result that an expression like $\sum_{\ell \in S_{mm}} r^{mm}_{k\ell}\, h_{m\ell}$ can be approximated as

$$\sum_{\ell \in S_{mm}} r^{mm}_{k\ell}\, h_{m\ell} = (1-\kappa_m)\, \bar{h}_{mmk} + \kappa_m\, \bar{\bar{h}}_m + \text{error term}, \tag{3.8}$$

where the error term has mean zero and is independent of the other terms on the right hand side of (3.8); κ_m is a parameter, $0 \le \kappa_m \le 1$; $\bar{\bar{h}}_m$ is the mean number of hours worked by all males in society; $\bar{h}_{mmk}$ is the mean number of hours worked by all males in the <u>social group</u> of the male. A social group is defined as the set of all males who have identical characteristics, i.e. they are in the same age bracket, they have the same level of schooling, etc. (see Section 4 for details). The parameter κ_m is an indicator of how informative a social group is about the reference group of an individual. For instance, if $\kappa_m = 0$ then (3.8) implies that the social group mean is a good indicator of the reference group mean. On the other hand, if $\kappa_m = 1$, the social group mean conveys no information whatsoever about the reference group mean.

Similar to (3.8), we obtain as an approximation for $\sum_{\ell \in S_{fm}} s_{k\ell}^{mm} h_{m\ell}$

$$\sum_{\ell \in S_{fm}} s_{k\ell}^{mm} h_{m\ell} = (1-\kappa_m)\, \bar{h}_{fmk} + \kappa_m . \bar{\bar{h}}_m + \text{error term}, \tag{3.9}$$

where $\bar{h}_{fmk}$ is the mean of male working hours in the social group of the female in family k (i.e. all males with characteristics equal to the characteristics of this female). Expressions similar to (3.8) and (3.9) are obtained for the various other reference group means that play a role in (3.3) and (3.4).

Relations like (3.8) and (3.9) lead to a further partitioning of society on the basis of reference weights assigned to different people. Similar to Fig. 1, the final partitioning of society on the basis of the weighting by the male in family k is illustrated in Fig. 2. A similar diagram can be drawn for the female in family k.

Thus far we have not taken demographic factors into account in our analysis. The effect of household size has also been incorporated by means of translating. That is, equation (3.1) and (3.2) have been replaced by

$$\begin{aligned}\delta_{mk} = \delta_{m0} + \pi_m . fs_k + \eta_{mm} \sum_{\ell \in P_m} v_{k\ell}^{mm}(h_{m\ell}(-1) - \pi_m fs_\ell) \\ + \eta_{mf} \sum_{\ell \in P_f} v_{k\ell}^{mf}(h_{f\ell}(-1) - \pi_f fs_\ell)\end{aligned} \tag{3.10}$$

$$\begin{aligned}\delta_{fk} = \delta_{f0} + \pi_f . fs_k + \eta_{ff} \sum_{\ell \in P_f} v_{k\ell}^{ff}(h_{f\ell}(-1) - \pi_f fs_\ell) \\ + \eta_{fm} \sum_{\ell \in P_m} v_{k\ell}^{fm}(h_{m\ell}(-1) - \pi_m fs_\ell),\end{aligned} \tag{3.11}$$

where we have defined "family size" fs_ℓ as the logarithm of the number of persons in household ℓ.

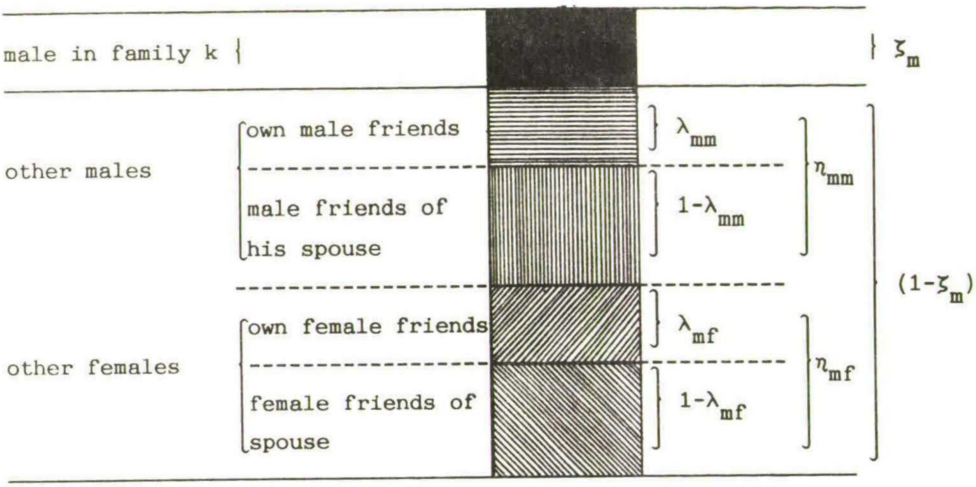

Fig. 1 A partition of the reference group of the male in family k.

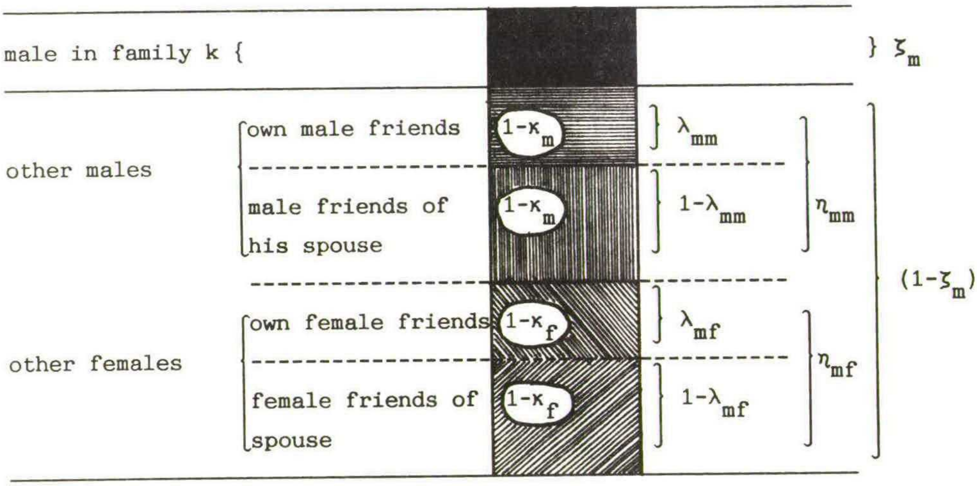

Fig. 2 The final partition of the reference group of the male in family k.

Going through the same procedure as described above finally yields the following expressions for the delta's:

$$\delta_{mk} = \delta_{m0} + \pi_m fs_k + \eta_{mm}[\zeta_m(h_{mk}(-1) - \pi_m . fs_k) + (1-\zeta_m)\{\kappa_m(\bar{\bar{h}}_m(-1) - \pi_m \bar{\bar{fs}}) + (1-\kappa_m)(\lambda_{mm}(\bar{h}_{mmk}(-1) - \pi_m \bar{fs}_{mk}) + (1-\lambda_{mm})(\bar{h}_{fmk}(-1) - \pi_m \bar{fs}_{fk}))\}] + \eta_{mf}[\kappa_f(\bar{\bar{h}}_f(-1) - \pi_f . \bar{\bar{fs}}) + (1-\kappa_f)\ (\lambda_{mf}(\bar{h}_{mfk}(-1) - \pi_f \bar{fs}_{mk}) + (1-\lambda_{mf})(\bar{h}_{ffk}(-1) - \pi_f \bar{fs}_{fk}))] + \psi_{mk} \qquad (3.12)$$

$$\delta_{fk} = \delta_{f0} + \pi_f fs_k + \eta_{ff}[\zeta_f(h_{fk}(-1) - \pi_f fs_k) + (1-\zeta_f).\{\kappa_f(\bar{\bar{h}}_f(-1) - \pi_f \bar{\bar{fs}}) + (1-\kappa_f)(\lambda_{ff}(\bar{h}_{ffk}(-1) - \pi_f \bar{fs}_{fk}) + (1-\lambda_{ff})(\bar{h}_{mfk}(-1) - \pi_f \bar{fs}_{mk}))\}] + \eta_{fm}[\kappa_m(\bar{\bar{h}}_m(-1) - \pi_m \bar{\bar{fs}}) + (1-\kappa_m)(\lambda_{fm}(\bar{h}_{fmk}(-1) - \pi_m \bar{fs}_{fk}) + (1-\lambda_{fm})(\bar{h}_{mmk}(-1) - \pi_m \bar{fs}_{mk}))\} + \psi_{fk} \qquad (3.13)$$

where fs_k := logarithm of the size of household k

$\bar{fs}_{mk}$:= mean of the logarithm of the size of the households in the social group of the male in family k.

$\bar{fs}_{fk}$:= mean of the logarithm of the size of the households in the social group of the female in family k.

$\bar{\bar{fs}}$:= mean of the logarithm of the size of the households in society as a whole.

π_m, π_f are parameters

ψ_{mk}, ψ_{fk} are random variables with mean zero and independent of the other variables on the right hand side of (3.12) - (3.13).

By now we have constructed a flexible neo-classical labor supply model in which habit formation and preference interdependence are incorporated by means of translating. We will refer to this model as the "extended model". An important issue is the identification of the parameters. From the labor supply equations (2.1) - (2.3) it is easy to see that the standard model is (over)identified. Thus, if we examine the identification of the extended model with preference formation, we can confine ourselves to examination of the equations for the δ's. A discussion of the identifiability of the parameters can be found in Appendix 2. At this stage it is sufficient to notice that all but two parameters (κ_m, κ_f) are identified.

4. Estimation Results

Appendix 1 summarizes the complete specification of the model. The model has been estimated by means of maximum likelihood for data on 847 households from a labor mobility survey in The Netherlands, conducted in 1985. The specification of the likelihood is given in Appendix 3. Sample information about the main variables of interest is given in Table 1.

Table 1: Sample characteristics

		mean in the subsample of working individuals
male	actual hours per week	42.23
	actual hours per week, lagged 1 year	40.60
	preferred hours per week	38.83
	net wage rate[a)]	13.66
female	actual hours per week	27.38
	actual hours per week, lagged 1 year	30.78
	preferred hours per week	24.70
	net wage rate[a]	10.60

a) Based on predicted wages. The wage equations used for prediction are given in Appendix 4.

Table 2 contains a description of the labor force participation of the individuals in the sample.

Table 2: Sample composition

female \ male	working	no benefit: not working, looking for a job	no benefit: not working, not looking for a job	benefit: not working, looking for a job	benefit: not working, not looking for a job	
no benefit						
working	314	4	2	9	1	330
not working, looking for a job	26	0	0	4	0	30
not working, not looking for a job	450	0	0	25	0	475
benefit						
not working, looking for a job	6	0	0	2	0	8
not working, not looking for a job	3	0	0	1	0	4
	799	4	2	41	1	847

As mentioned in Section 3, the sample of individuals has been partioned in social groups in which the individuals have identical characteristics. The characteristics considered are age and education level. (four and five categories, respectively) In Table 3 social group means are presented of working hours lagged one year. These means are not only based on information for the 847 households used in estimation, but also on the number of hours worked by single males and females. Single individuals are represented in the sample, but the modelling of their behavior is not the subject of this paper. The main results of the maximum likelihood estimation of the model for households are presented in Table 4.

A comparison of the log-likelihood values corresponding to the extended model and the standard model makes it clear that preference formation is a highly significant factor in household labor supply. Yet, the estimation result for the extended model are not uniformly satisfactory. The estimates for η_{fm} and ζ_m had to be constrained by a lower limit (zero) and an upper limit (one) respectively. As a result λ_{mm} and λ_{fm} are not identifiable (See (3.12) and (3.13)). Generally, social group means of male hours seem to have little impact.

One explanation for this may be that male hours in The Netherlands are pretty much institutionally determined. The variation in social group means of male hours shown in Table 3 therefore mainly reflects variation across the life-cycle and across education levels of school enrollment, involuntary unemployment and disability[1]. The households whose labor supply we are trying to explain contain two able-bodied spouses who are available for market work. These households' reference groups may hardly contain the school-going, the disabled or even the unemployed. If this is true, the use of social group means to approximate reference group means may be a poor practice. Without data that contains more specific information about reference groups there is not too much we can do. For females the situation is less bleak, because their working hours are less affected by institutional constraints and hence the observed variation in social group means are probably more representative of variation in reference group means.

The parameters σ_{vm} and σ_{vf} in Table 4 represent the standard deviation of the random component in the utility difference between working

2) For instance, in the age group 45-65 37 per cent of the male population in The Netherlands is on disability.

Table 3: Social group means[b]

education level[a]

age	male 1	male 2	male 3	male 4	female 1	female 2	female 3	female 4	
18-30	0.82	0.84	0.70	0.50	0.92	0.95	0.78	0.57	log (family size)
	32.44	35.06	34.22	29.98	12.74	16.23	20.21	24.83	hours worked, lagged one year
	43	88	134	58	74	112	235	65	number of individuals
30-40	1.18	1.11	1.16	1.08	1.26	1.28	1.20	0.94	
	40.80	38.69	40.50	38.69	7.43	4.90	11.35	18.63	
	71	96	281	160	136	146	234	92	
40-50	1.28	1.25	1.26	1.28	1.26	1.34	1.28	1.17	
	34.11	37.78	39.35	39.69	6.01	4.66	9.90	17.98	
	74	85	161	107	112	118	135	50	
50-65	0.90	1.02	1.05	0.96	0.96	0.87	0.83	0.64	
	20.99	29.56	31.89	34.15	2.95	7.36	9.86	13.08	
	136	69	159	93	166	92	84	24	

a) Education has been coded in 5 levels ranging from 1 (lowest) till 5 (highest).

b) 3690 individuals in households and single persons were used to form the social group means.

Table 4: Estimation Results[a,b]

parameters	extended model		standard model $\eta_m = \eta_f = 0$ (no preference formation)	
α	0.145*	(0.003)	- 0.003	(0.008)
β_m	- 0.0008	$(0.3 * 10^{-5})$	- 0.0015*	$(0.3 * 10^{-5})$
β_f	- 0.0027*	$(0.7 * 10^{-5})$	- 0.0002*	$(0.1 * 10^{-4})$
γ_m	0.106*	(0.006)	0.312*	(0.015)
γ_f	1.27*	(0.05)	2.16*	(0.08)
π_m	2.21		1.1*	(0.2)
π_f	-1033*	(30.1)	- 40.6*	(0.7)
δ_{m0}	80.9*	(0.2)	130*	(0.2)
δ_{f0}	180*	(0.5)	35.0*	(0.9)
ϑ	71087*	(147)	62565*	(148)
η_{mm}	0.210*	(0.006)	0	
η_{ff}	0.998*	(0.005)	0	
η_{mf}	0.13*	(0.02)	0	
η_{fm}	0 (l.b)		0	
ζ_m	1 (u.b)		-	
ζ_f	0.993*	(0.002)	-	
λ_{mm}	-		-	
λ_{ff}	0.98	(0.89)	-	
λ_{mf}	0.53	(0.48)	-	
λ_{fm}	-		-	
σ_m	6.00*	(0.08)	6.33*	(0.07)
σ_f	12.7*	(0.3)	21.7*	(0.9)
σ_{vm}	7069	(1075)	2616*	(590)
σ_{vf}	4708	(9393)	3209	(33575)
ρ	- 0.07*	(0.04)	- 0.08*	(0.04)
log likelihood	-4114.07		-4400.65	

a) It is not possible to identify the parameters κ_m, κ_f. We have assumed both to be equal to 0.5.

b) * := absolute t value > 1.6
Standard errors in parentheses.

an optimal number of hours without unemployment benefits and working zero hours with unemployment benefits. Their values are rather inaccurately determined, mainly because in the sample there is only a small number of individuals who have to make this utility comparison (cf. Table 2). The small but significant value of ρ indicates some correlation in the labor supply equations for the male and the female. Finally, it should be mentioned that concavity of the household cost function is satisfied in all data points for both the standard and the extended model.

Turning now to the economic interpretation of the results, we note that both columns of Table 4 show negative income effects, implying leisure to be a normal good, and positive own linear wage effects. Moreover we see that in both models family size has a positive effect on the male's labor supply and a negative on the female's. The huge value of π_f (-1033) in the extended model is due to the fact that ζ_f is close to 1. In fact the reduced form coëfficient for (log) family size is $\pi_f(1-\eta_{ff}\zeta_f) + \beta_f \cdot \left[\pi_n\left[1-\eta_{nn}\zeta_m\right]w_m + \pi_f\left[1-\eta_{ff}\zeta_f\right]w_f\right] = -9$ (See Appendix 2). This means that if a family of 2 is extended to three persons, the wife works 3,5 hours less per week. A second child reduces the wife's working hours by 2,6 more hours per week. In the standard model the first child reduces the number of working hours of the wife by 16, the second child by 11 additional hours.

Male labor supply appears to be less influenced by preference formation than female labor supply (the sum of η_{mm} and η_{mf} is smaller than the sum of η_{ff} and η_{fm}). Furthermore, both men and women refer to women only. A possible explanation for this finding was given above. For both male and female the importance of habit formation relative to preference interdependence is overwhelming ($\zeta_m = 1$, $\zeta_f = 0.993$). A high λ_{ff} (0.979) means that a female's social group mainly consists of women of her own age and education, and hardly of any women of the same age and education as her husband. A value of λ_{mf} of about $\frac{1}{2}$ implies that men refer to women of their own age and education as well as to women of the same age and education as their wives. Table 5 summarizes the "total" influence of habit formation and preference interdependence on the parameters δ_{mk} and δ_{fk}[1].

3) These numbers are invariant to the (arbitrary) choice of the unidentified parameters κ_m and κ_f.

The small influence of preference interdependence is clear from this table. Yet, as will be seen below, preference interdependence does make a significant contribution.

Table 5: "Total influence of habit formation and preference interdependence

	influence on		
influence of		δ_{mk}	δ_{fk}
$h_{mk}(-1)$	own lagged hours (male)	0.210	-
$h_{fk}(-1)$	own lagged hours (female)	-	0.991
$\bar{h}_{mmk}(-1)$	s.g. mean of male hours in s.g. of male	0	0
$\bar{h}_{ffk}(-1)$	s.g. mean of female hours in s.g. of female	0.031	0.003
$\bar{h}_{mfk}(-1)$	s.g. mean of female hours in s.g. of male partner	0	0.000
$\bar{h}_{fmk}(-1)$	s.g. mean of male hours in s.g. of female partner	0.034	0
$\bar{\bar{h}}_{m}(-1)$	population mean of male hours	0	0
$\bar{\bar{h}}_{f}(-1)$	population mean of female hours	0.065	0.003

In Tables 6 and 7 more estimation results are presented for various alternative specifications of the model. (For reasons of space standard errors are omitted.) These shed light on the robustness of the results discussed so far. From the first two columns in Table 6 it can be concluded that the lambdas are hardly identified. Different lambda values lead to almost the same estimation results. For that reason we take the λ's fixed from now on. Columns 3 and 4 show that the hypothesis $\eta_{mf} = 0$ and $\eta_{fm} = 0$ can be rejected at the 0.5% level. Consequently, the hypothesis of no preference interdependence can be rejected. The hypothesis of no habit formation ($\zeta_m = \zeta_f = 0$) is even more decisively rejected (column 5).

The last column of Table 6 is analogous to the first column of Table 4, except for one difference. The results of Table 4 are based on wage equations which are estimated jointly for working and non-working individuals. For working individuals, their actual wage is used; for non-working individuals, the wage they expect to receive in case they should find a job. The last column of Table 6 is based on a wage equation which is estimated for working individuals only and with correction for selection bias. One observes that the two procedures lead to almost identical estimates for the β-s, γ-s, ζ-s, α-s, η-s.

Table 7 presents results for some additional versions of the model. The estimates in Table 7 are based on a subsample of 796 households from which all recipients of benefits have been removed. Comparison of the first two columns in Table 7 with Table 4 reveals some differences. In particular γ_m, the labor supply response of the male to his own wage is quite a bit larger in Table 7. In view of Table 2, this need not surprise us. There are 42 males who are receiving benefits and 41 of those report to be looking for a job. On the other hand, out of the six male unemployed who do not receive a benefit, four are looking for a job. This would suggest that money plays no role in a male's decision to work. In estimation, this shows up as a small value for γ_m. However, the answers obtained in the questionnaire to the question whether a respondent is looking for a job may be biased toward an affirmative answer because in The Netherlands job seeking is a prerequisite for receiving unemployment benefits. Thus, the results obtained for the subsample without recipients of benefits may be more reliable than the ones presented in Table 4.

We also re-estimated the model without the assumption of rationing, thus deleting a possible endogeneity problem. The problem might arise if actual hours (which appear in the shadow wages) depend on current preferred hours. In that case male preferred hours depend on female actual hours (via the shadow wage (cf. KKS and Appendix 1). And female actual hours may depend on female preferred hours. That generates a system of simultaneous equations. In the model summarized in Appendix 1 we have assumed that actual hours do <u>not</u> depend on current preferred hours although they may depend on lagged preferred hours. Comparison of the first two columns of Table 7 and the second two columns yields almost identical estimation results. This suggests that the potential endogeneity problem is not serious. It also suggests that rationing is not an important problem.

Table 6. Estimation results for various versions of the extended model[a)]

	λ-s fixed		λ-s fixed, $\eta_{mf}=\eta_{fm}=0$		no habit formation	wage predictions on actual wages only
	$\lambda_{mm}=\lambda_{ff}=\lambda_{mf}=\lambda_{fm}=1$	$\lambda_{mm}=\lambda_{ff}=\lambda_{mf}=\lambda_{fm}=\frac{1}{2}$	λ-s = 1	λ-s = $\frac{1}{2}$		
α	0.151	0.152	0.060	0.060	0.036	0.146
β_m	- 0.0008	- 0.0008	- 0.0015	- 0.0015	- 0.0015	- 0.0007
β_f	- 0.0027	- 0.0027	- 0.0009	- 0.0009	- 0.0006	- 0.0027
γ_m	0.105	0.106	0.298	0.303	0.310	0.101
γ_f	1.28	1.28	1.08	1.07	1.78	1.26
π_m	2.21	2.21	1.09	1.04	1.10	2.21
π_f	- 1035	- 1034	- 856	- 794	- 41.4	- 1050
δ_{m0}	80.8	80.5	123	124	130	79.2
δ_{f0}	178	178	37.7	37.7	11.5	180
ϑ	72655	72870	65149	66099	62911	74503
η_{mm}	0.207	0.210	0.201	0.225	0 (l.b)	0.210
η_{ff}	1 (u.b)	1 (u.b)	1 (u.b)	1 (u.b)	1 (u.b)	0.994
η_{mf}	0.205	0.258	0	0	0	0.251
η_{fm}	0.002	0.002	0	0	0	0.008
ζ_m	1 (u.b)	1 (u.b)	1 (u.b)	0.892	0	1 (u.b)
ζ_f	0.991	0.991	0.989	0.988	0	0.998
λ_{mm}	1	1/2	1	1/2	1	-
λ_{ff}	1	1/2	1	1/2	1	-
λ_{mf}	1	1/2	1	1/2	-	-
λ_{fm}	1	1/2	1	1/2	-	-
σ_m	6.01	6.00	6.05	6.05	6.33	6.01
σ_f	12.6	12.6	12.8	12.8	20.8	12.6
σ_{vm}	7071	7070	2549	2386	2618	7095
σ_{vf}	4712	4712	2408	2230	3211	4718
ρ	- 0.074	- 0.073	- 0.032	- 0.027	- 0.087	- 0.087
log likelihood	-4115.46	- 4115.01	-4127.19	- 4126.13	-4389.18	- 4118.52

a) u.b. := upper bound, l.b. := lower bound

Table 7. Estimation results for the standard and the extended model. Sub-sample of non-recipients of benefits

	standard model	extended model	without rationing, endogeneous variable: preferred hours, standard m	extended m	endogeneous variable: actual hours, standard m	extended m
α	- 0.031	0.048	- 0.0003	0.0007	- 0.0008	- 0.034
β_m	- 0.0015	- 0.0015	- 0.0015	- 0.0014	- 0.0011	- 0.0008
β_f	0.0002	- 0.0008	- 0.0002	- 0.0009	- 0.0001	- 10^{-5}(l.b)
γ_m	0.312	0.316	0.310	0.296	0.213	0.077
γ_f	2.36	0.905	2.29	0.899	2.74	0.832
π_m	1.26	1.191	1.38	1.09	1.62	0.620
π_f	-41	- 818	-41.0	- 842	-46.7	-3129
δ_{m0}	130	127	129	123	131	65.8
δ_{f0}	35.9	36.3	35.4	40.1	34.9	-16.1
ϑ	62379	67065	62563	65314	83145	62539
η_{mm}	0	0.212	0	0.212	0	0.618
η_{ff}	0	1 (u.b)	0	1 (u.b)	0	1 (u.b)
η_{mf}	0	0	0	0	0	0
η_{fm}	0	0	0	0	0	0
ζ_m	-	1 (u.b)	-	1 (u.b)	-	0.572
ζ_f	-	0.989	-	0.990	-	0.996
λ_{mm}	-	-	-	-	-	1
λ_{ff}	-	1	-	1	-	1
λ_{mf}	-	-	-	-	-	-
λ_{fm}	-	-	-	-	-	-
σ_m	6.30	6.04	6.32	6.04	6.91	6.19
σ_f	21.3	12.8	21.3	12.9	23.7	12.4
σ_{vm}	-	-	-	-	-	-
σ_{vf}	-	-	-	-	-	-
ρ	- 0.028	- 0.014	- 0.086	- 0.073	0.006	0.014
log likelihood	-4282.21	-4019.05	- 4281.78	-4020.19	-4385.54	-4036.37

a) u.b. := upper bound, l.b. := lower bound

In the last two columns of this table results are presented of the estimation with actual hours as the endogenous variable instead of preferred hours and without application of rationing theory. Although we realize that there might be noise in the data on preferred hours due to interpretation problems, we feel that preferred hours is the appropriate variable in a model that describes the supply side of the labor market. For the basic model the two versions do not differ very much. Looking at the values of the log-likelihood, it seems that preferred hours are explained somewhat better by the model than actual hours. However, since the two versions are not nested, no inference can be made from this difference in the values of the log likelihood. In the extended model especially the parameters corresponding to preference formation differ quite a bit. But the wage and income coëfficients are also smaller in the actual hours version than in the preferred hours version. The obvious explanation for this is that actual hours are largely determined by institutional constraints. Here too, the version with preferred hours yields a higher value of the log-likelihood than the actual hours version.

To illustrate how the model works, Figs. 3 and 4 present labor supply curves for a family without children. All variables not shown in the diagrams have been set equal to their sample means. For the extended model, we distinguish between short term and long term supply curves. The short term supply curve of the male describes the relation between his (after tax) wage rate and the number of hours he wants to work per week, assuming that nothing else (including his partner's actual number of hours) changes. A similar definition applies to the female short run supply curve.

In the definition of a long run supply curve we want to account for habit formation and for the fact that a change in behavior of one individual affects the behavior of others. Thus, to define a long run supply curve of males, we start out by assigning all males the same wage, leaving all other exogeneous variables unaffected. Assuming that individuals are able to realize their preferred number of hours, the model generates equilibrium values of the weekly number of hours worked for all males (and for all females). We call this the long run labor supply of males. By varying the male wage rate, we trace out the effect of a change in the male wage rate on labor supply in society. Long run female labor supply curves are defined analogously. For reasons of space we only present labor supply responses of households without children.

Figure 3 shows a very flat male labor supply curve and there is hardly any difference between the short and the long run. Due to the positive cross wage effect, men want to work more hours the higher the wife's wage rate is. Both the wife's short term and long term labor supply curve is forward bending, which means that the positive own wage effect dominates the negative income effect. The kink in the long term curve is caused by the fact that at wage rate increases until a wage rate of 20 female labor force participation rises dramatically, although at first the new entrants only work a few hours a week. The long term supply curve is steeper than the short term one due to interdependence of preferences and habit formation.

Figure 4 shows labor supply curves from the standard model. In this case the short term and the long term curves differ only in that for the short term the spouse's number of actual hours is kept constant, but in the long run these are allowed to change to optimal values, i.e there is then no longer any rationing. Once again we see a steep female labor supply curve and a flat male labor supply curve. Cross wage effects are also small.

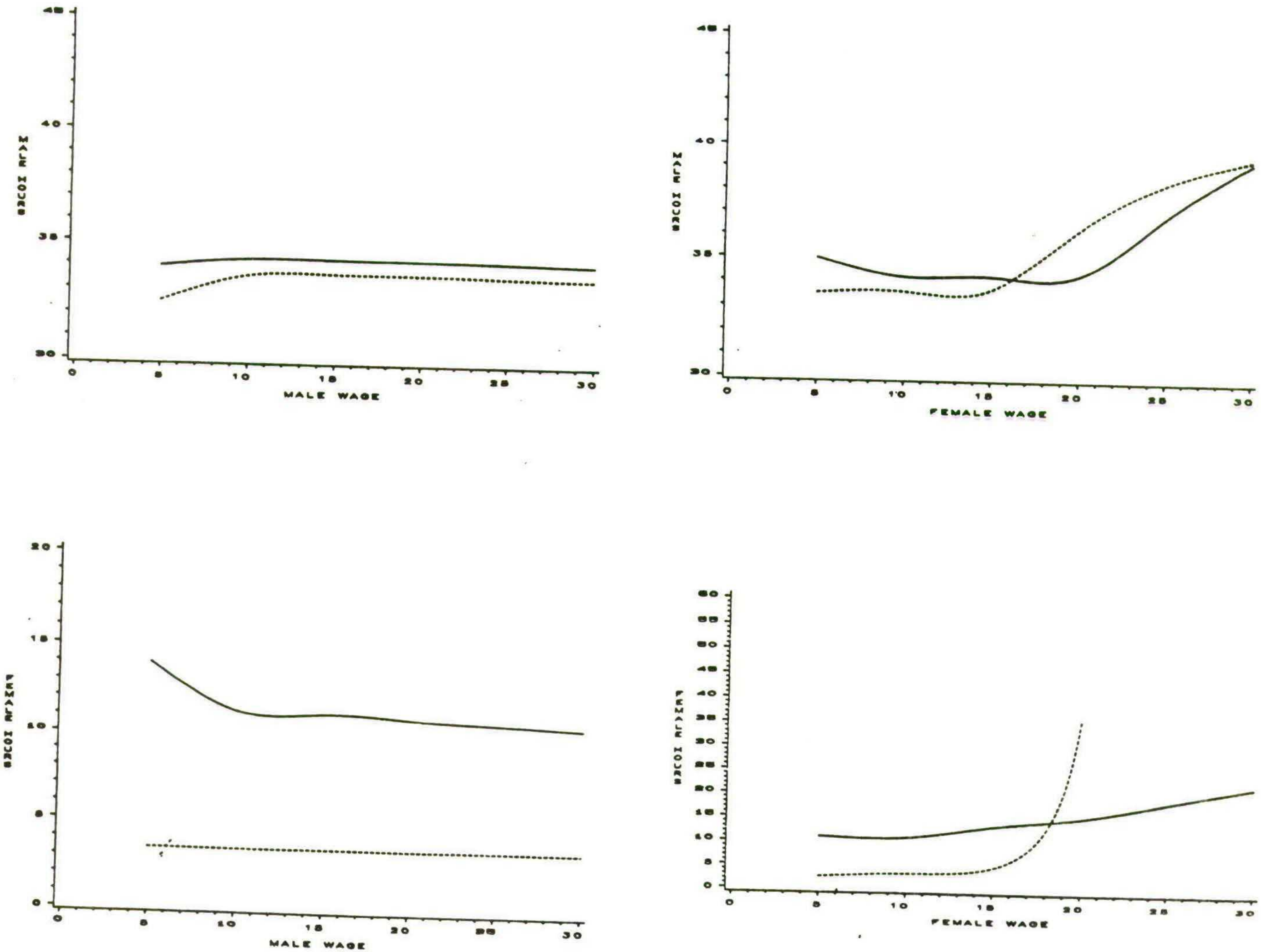

Figure 3. Labor supply curves in the extended model (- - - := long run, ——— := short run)

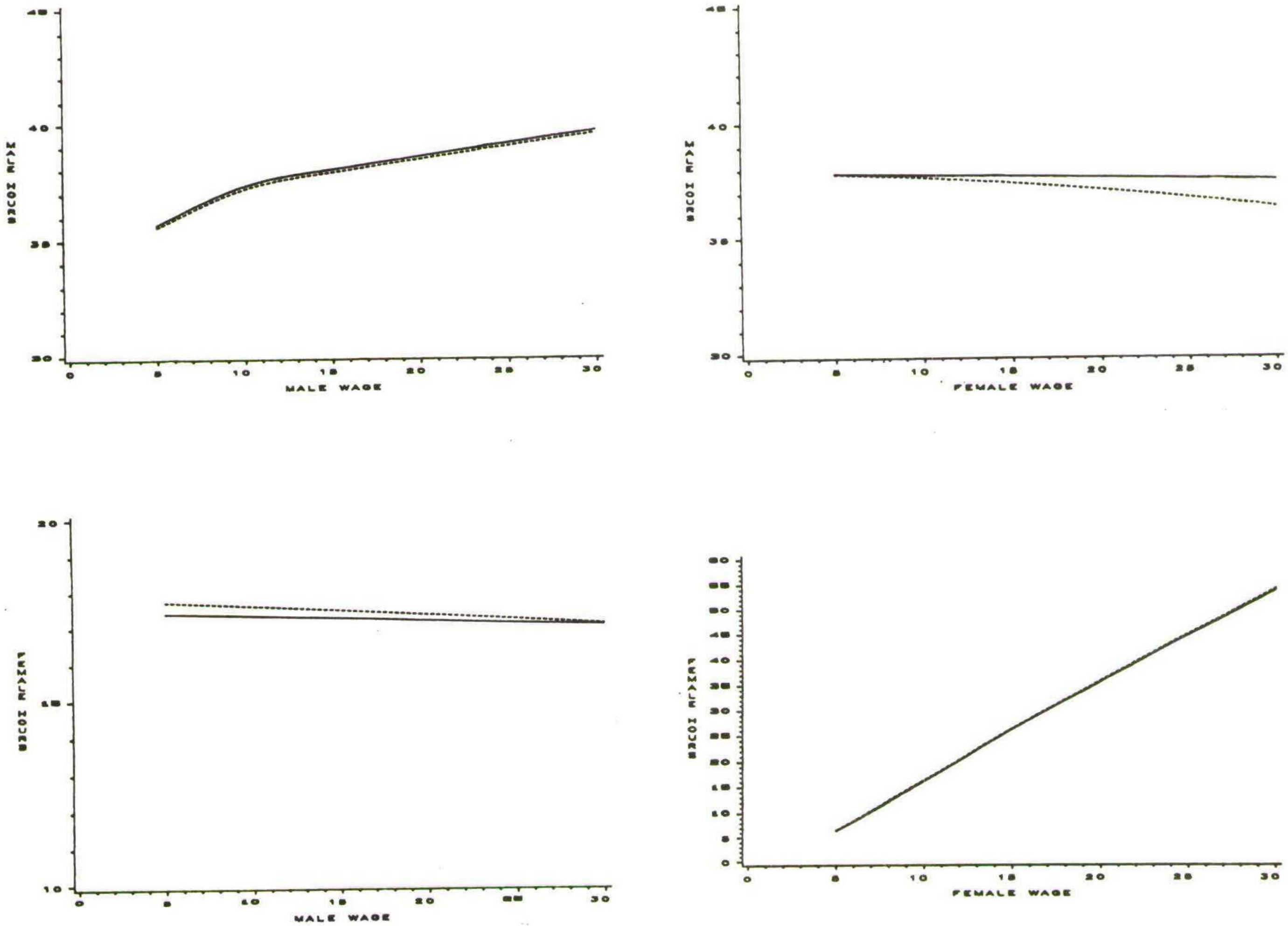

Figure 4. Labor supply curves in the standard model (– – – := long run, ——— := short run)

Conclusions

It is encouraging to find that our extended model explains household labor supply significantly better than the standard model. However the lack of strong preference interdependence was surprising, considering other empirical studies, which dealt with interdependence in consumption. (cf. Kapteyn et. al (1984), Kapteyn and Alessie (1986)). In the model with preference formation, short term wage effects are small, but long term effects are larger. This implies that for policy purposes considerable attention should be given to the timing of policy measures.

There are a few important limitations to this study that deserve attention. First, the simple way in which dynamics in behavior is incorporated needs to be improved. This can only be done when panel data are available. Secondly, the stochastic specification of the supply equations needs improvement, because random preferences are ruled out by our specification (See KKS). It would be of interest to extend the model with random preferences. Thirdly, more attention should be given to the measurement of reference groups. In the present paper reference groups were constructed by assumption. Direct empirical information on the composition of reference groups is of crucial importance for the improvement of the model.

Despite these shortcomings, the empirical results so far suggest it to be worthwile to take social psychological variables into account when analyzing labor supply behavior.

Appendix 1 Details of the Standard Model

Let $\tilde{h}^r_{mk}$ and $\tilde{h}^r_{fk}$ be the preferred number of hours of the male and the female in family k, given that the partner is rationed at his or her actual number of hours. The values of $\tilde{h}^r_{mk}$ and $\tilde{h}^r_{fk}$ are then generated by rationed versions of (2.1) - (2.3) as follows:

$$\tilde{h}^r_{mk} = \delta_{mk} + \gamma_m w_{mk} + \alpha \bar{w}_{fk} + \beta_m . \bar{\mu}^{f*}_k , \qquad (A.1)$$

$$k=1,\ldots,N$$

$$\tilde{h}^r_{fk} = \delta_{fk} + \gamma_f w_{fk} + \alpha \bar{w}_{mk} + \beta_f . \bar{\mu}^{m*}_k , \qquad (A.2)$$

$$\bar{\mu}^{f*}_k = \mu_k + \vartheta + \delta_{mk} w_{mk} + \delta_{fk} \bar{w}_{fk} + \tfrac{1}{2}(\gamma_m w^2_{mk} + \gamma_f \bar{w}^2_{fk}) + \alpha w_{mk} \bar{w}_{fk}$$

$$+ h_{fk}(w_{fk} - \bar{w}_{fk}) \qquad (A.3)$$

$$\bar{\mu}^{m*}_k = \mu_k + \vartheta + \delta_{mk} \bar{w}_{mk} + \delta_{fk} w_{fk} + \tfrac{1}{2}(\gamma_m \bar{w}^2_{mk} + \gamma_f w^2_{fk}) + \alpha \bar{w}_{mk} w_{fk}$$

$$+ h_{mk}(w_{mk} - \bar{w}_{mk}) \qquad (A.4)$$

$$h_{mk} = \delta_{mk} + \gamma_m \bar{w}_{mk} + \alpha w_{fk} + \beta_m . \bar{\mu}^{m*}_k \qquad (A.5)$$

$$h_{fk} = \delta_{fk} + \gamma_f \bar{w}_{fk} + \alpha w_{mk} + \beta_f . \bar{\mu}^{f*}_k , \qquad (A.6)$$

where

h_{mk} := actual number of hours worked by male

h_{fk} := actual number of hours worked by female

Equations (A.5) and (A.6) define the shadow wages $\bar{w}_{mk}$ and $\bar{w}_{fk}$ used in (A.1) - (A.2).

To make this an estimable model, a stochastic specification is added to the model. For individuals who do not receive a benefit this yields the following explanation of preferred hours:

$$h^p_{mk} = \tilde{h}^r_{mk} + \varepsilon_{mk} \quad \text{if } \tilde{h}^r_{mk} + \varepsilon_{mk} \geq 0$$
$$= 0 \quad \text{if } \tilde{h}^r_{mk} + \varepsilon_{mk} < 0 \tag{A.7}$$

$$h^p_{fk} = \tilde{h}^r_{fk} + \varepsilon_{fk} \quad \text{if } \tilde{h}^r_{fk} + \varepsilon_{fk} \geq 0$$
$$= 0 \quad \text{if } \tilde{h}^r_{fk} + \varepsilon_{fk} < 0 \tag{A.8}$$

$$\begin{bmatrix} \varepsilon_{mk} \\ \varepsilon_{fk} \end{bmatrix} \sim N\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma^2_m & \rho\sigma_m\sigma_f \\ \rho\sigma_m\sigma_f & \sigma^2_f \end{bmatrix} \right) \tag{A.9}$$

where h^p_{mk} and h^p_{fk} are observed preferred hours of man and women and ε_{mk} and ε_{fk} are error terms.

For individuals who receive a benefit we compute the utility U^i_{1k} (i=f,m) of working an optimal number of hours without a benefit, and the utility U^i_{0k} (i=f,m) of not working and receiving a benefit. To allow for stochastic preference variation we add a random error term to the difference $U^i_{1k} - U^i_{0k}$. The model for these individuals is now written as follows:

For individuals who receive a benefit:
Define:

$$V_{mk} = U^m_{1k} - U^m_{0k} + v_{mk} \tag{A.10}$$

$$V_{fk} = U^f_{1k} - U^f_{0k} + v_{fk} \tag{A.11}$$

$$v_{mk} \sim N\left(0, \sigma^2_{vm}\right), \; v_{fk} \sim N\left(0, \sigma^2_{vf}\right) \tag{A.12}$$

v_{mk} is assumed uncorrelated with ε_{fk} and so is v_{fk} with ε_{mk}.

$$h^p_{mk} = \tilde{h}^r_{mk} + \varepsilon_{mk} \text{ if } \tilde{h}^r_{mk} + \varepsilon_{mk} \geq 0 \text{ and } U^m_{1k} - U^m_{0k} + v_{mk} \geq 0$$
$$= 0 \quad \text{if } \tilde{h}^r_{mk} + \varepsilon_{mk} < 0 \text{ or } U^m_{1k} - U^m_{0k} + v_{mk} < 0 \tag{A.13}$$

$$h^p_{fk} = \tilde{h}^r_{fk} + \varepsilon_{fk} \text{ if } \tilde{h}^r_{fk} + \varepsilon_{fk} \geq 0 \text{ and } U^f_{1k} - U^f_{0k} + v_{fk} \geq 0$$
$$= 0 \qquad \text{if } \tilde{h}^r_{fk} + \varepsilon_{fk} < 0 \text{ or } U^f_{1k} - U^f_{0k} + v_{fk} < 0 \tag{A.14}$$

The extended model is obtained from the standard model by parametrizing δ_{mk} and δ_{fk} according to (3.15) - (3.16).

Appendix 2 Identification

The model without preference formation is (over)identified. Thus it is sufficient to examine the delta-equations (3.12) - (3.13) for identification of the model with preference formation.

Table A1.1 presents equation (3.12) - (3.13) in a slightly different form. From this table we infer there are 18 reduced-form parameters (a_1 - a_{18}) and 16 structural parameters, namely: η_{mm}, η_{ff}, η_{mf}, η_{fm}, λ_{mm}, λ_{ff}, λ_{mf}, λ_{fm}, ζ_m, ζ_f, κ_m, κ_f, π_m, π_f, δ_{m0}, δ_{f0}. It is easy to see that from a_1 and a_6 π_m can be identified, and likewise π_f from a_{10} and a_{15}. From a_2 and a_4 λ_{mm} can be identified, from a_3 and a_5 λ_{mf}, from a_{11} and a_{13} λ_{fm} and from a_{12} and a_{14} λ_{ff}. This leaves us with 12 equations (a_1, $a_2 + a_4$, $a_3 + a_5$, a_7, a_8, a_9, a_{10}, $a_{11} + a_{13}$, $a_{12} + a_{14}$, a_{16}, a_{17}, a_{18}) to identify 10 parameters (η_{mm}, η_{ff}, η_{fm}, η_{mf}, ζ_m, ζ_f, κ_m, κ_f).

The equations a_7 and a_8 do not yield independent identifying information, and neither do the equations a_{16} and a_{17}. For these equations can be written as follows:

$$a_7 = -a_2 \cdot \pi_m - a_5 \cdot \pi_f \tag{A.15}$$

$$a_8 = -a_4 \cdot \pi_m - a_3 \cdot \pi_f \tag{A.16}$$

$$a_{16} = -a_{14} \cdot \pi_f - a_{11} \cdot \pi_m \tag{A.17}$$

$$a_{17} = -a_{12} \cdot \pi_f - a_{13} \cdot \pi_m \tag{A.18}$$

In fact we have only 8 independent equations (a_1, $a_2 + a_4$, $a_3 + a_5$, a_9, a_{10}, $a_{11} + a_{13}$, $a_{12} + a_{14}$, a_{18}) to identify 10 parameters. If 2 parameters are fixed, the remaining 8 parameters are identified.[1] Overall it is necessary to fix only 2 parameters to identify the extended model.

1) Special combinations of fixed parameters still cause problems (for example fixed η_{mm} and ζ_m).

Table A.1: The delta-equations

independent variables \ dependent variables	δ_m s.p.[a]	δ_m r.f.p.[a]	δ_f s.p.[a]	δ_f r.f.p.[a]
$h_{mk}(-1)$	$\eta_{mm}\zeta_m$	a_1	-	
$h_{fk}(-1)$	-		$\eta_{ff}\zeta_f$	a_{10}
$\bar{h}_{mmk}(-1)$	$\eta_{mm}(1-\zeta_m)(1-\kappa_m)\lambda_{mm}$	a_2	$\eta_{fm}(1-\kappa_m)(1-\lambda_{fm})$	a_{11}
$\bar{h}_{ffk}(-1)$	$\eta_{mf}(1-\kappa_f)(1-\lambda_{mf})$	a_3	$\eta_{ff}(1-\zeta_f)(1-\kappa_f)\lambda_{ff}$	a_{12}
$\bar{h}_{fmk}(-1)$	$\eta_{mm}(1-\zeta_m)(1-\kappa_m)(1-\lambda_{mm})$	a_4	$\eta_{fm}(1-\kappa_m)\lambda_{fm}$	a_{13}
$\bar{h}_{mfk}(-1)$	$\eta_{mf}(1-\kappa_f)\lambda_{mf}$	a_5	$\eta_{ff}(1-\zeta_f)(1-\kappa_f)(1-\lambda_{ff})$	a_{14}
fs_k	$\pi_m(1-\eta_{mm}\zeta_m)$	a_6	$\pi_f(1-\eta_{ff}\zeta_f)$	a_{15}
$\overline{fs}_{mk}$	$-\eta_{mm}(1-\zeta_m)(1-\kappa_m)\lambda_{mm}\pi_m-\eta_{mf}(1-\kappa_f)\lambda_{mf}\pi_f$	a_7	$-\eta_{ff}(1-\zeta_f)(1-\kappa_f)(1-\lambda_{ff})\pi_f-\eta_{fm}(1-\kappa_m)(1-\lambda_{fm})\pi_m$	a_{16}
$\overline{fs}_{fk}$	$-\eta_{mm}(1-\zeta_m)(1-\kappa_m)(1-\lambda_{mm})\pi_m-\eta_{mf}(1-\kappa_f)(1-\lambda_{mf})\pi_f$	a_8	$-\eta_{ff}(1-\zeta_f)(1-\kappa_f)\lambda_{ff}\pi_f-\eta_{fm}(1-\kappa_m)\lambda_{fm}\pi_m$	a_{17}
constant term	$\delta_{m0}+\eta_{mm}(1-\zeta_m)\kappa_m(\bar{\bar{h}}_m(-1)-\pi_m\bar{\bar{fs}})+\eta_{mf}\kappa_f(\bar{\bar{h}}_f(-1)-\pi_f\bar{\bar{fs}})$	a_9	$\delta_{f0}+\eta_{ff}(1-\zeta_f)\kappa_f(\bar{\bar{h}}_f(-1)-\pi_f\bar{\bar{fs}})+\eta_{fm}\kappa_m(\bar{\bar{h}}_m(-1)-\pi_m\bar{\bar{fs}})$	a_{18}

For explanation of the variables, see Section 3.

a) s.p. : structural parameters

r.f.p.: reduced form parameters

Appendix 3. Likelihood Contributions

The likelihood function consists of different parts (L_k) corresponding with the different situations households are in. Let Φ and φ be the standard normal distribution function and density function respectively. Let $B\Phi$ and $b\varphi$ be the bivariate standard normal distribution function and density function, respectively (with correlation ρ).
We distinguish the following situations: (where i stands for m(ale) or f(emale))

1) $h^p_{ik} > 0$, $h^p_{jk} > 0$, $unbef_{ik} = 0$[1], $unbef_{jk} = 0$

$$L^1_k = \frac{1}{\sigma_i \cdot \sigma_j \cdot \sqrt{1-\rho^2}} \cdot b\varphi\left[\frac{h^p_{ik} - \tilde{h}^r_{ik}}{\sigma_i}, \frac{h^p_{jk} - \tilde{h}^r_{jk}}{\sigma_j}\right]$$

2) $h^p_{ik} = 0$, $h^p_{jk} > 0$, $unbef_{ik} = 0$, $unbef_{jk} = 0$

a) ik is <u>not</u> seriously looking for a job:

$$L^2_k = \Phi\left[\frac{-h^p_{ik}}{\sigma_i\sqrt{1-p^2}} - \frac{\rho\left[h^p_{jk} - \tilde{h}^r_{jk}\right]}{\sigma_j\sqrt{1-p^2}}\right] \cdot \frac{1}{\sigma_j}\,\varphi\left[\frac{h^p_{jk} - \tilde{h}^r_{jk}}{\sigma_j}\right]$$

b) ik is seriously looking for a job:

$$L^2_k = \left[1-\Phi\left[\frac{-h^p_{ik}}{\sigma_i\sqrt{1-\rho^2}} - \frac{\rho\left[h^p_{jk} - \tilde{h}^r_{jk}\right]}{\sigma_j\sqrt{1-\rho^2}}\right]\right] \cdot \frac{1}{\sigma_j}\,\varphi\left[\frac{h^p_{jk} - \tilde{h}^r_{jk}}{\sigma_j}\right]$$

3) In the sample none of the households consist of two non-working individuals, both without an unemployment benefit. Therefore specification of the likelihood contribution in this situation is omitted.

1) $Unbef_{ik}$:= unemployment benefit of the male or female in household k.

4) $h^p_{ik} = 0$, $h^p_{jk} > 0$, $unbef_{ik} > 0$, $unbef_{jk} = 0$

a) ik is <u>not</u> seriously looking for a job:

$$L^4_k = \left[1 - \left[1-\Phi\left[\frac{-h^p_{ik}}{\sigma_i\sqrt{1-\rho^2}} - \frac{\rho\left[h^p_{jk} - \tilde{h}^r_{jk}\right]}{\sigma_j\sqrt{1-\rho^2}}\right]\right]\right] \cdot \left[\Phi\left[\frac{\left[U^i_{1k} - U^i_{0k}\right]}{\sigma_{vi}}\right]\right]$$

$$\cdot \frac{1}{\sigma_j}\,\phi\left[\frac{h^p_{jk} - \tilde{h}^r_{jk}}{\sigma_j}\right]$$

b) ik is seriously looking for a job:

$$L^4_k = \left[1-\Phi\left[\frac{-\,h^p_{ik}}{\sigma_i\sqrt{1-\rho^2}} - \frac{\rho\left[h^p_{jk} - \tilde{h}^r_{jk}\right]}{\sigma_j\sqrt{1-\rho^2}}\right]\right] \cdot \left[\Phi\left[\frac{\left[U^i_{1k} - U^i_{0k}\right]}{\sigma_{vi}}\right]\right]$$

$$\cdot \frac{1}{\sigma_j}\,\phi\left[\frac{h^p_{jk} - \tilde{h}^r_{jk}}{\sigma_j}\right]$$

5) $h^p_{ik} = 0$, $h^p_{jk} = 0$, $unbef_{ik} > 0$, $unbef_{jk} = 0$

a) both ik and jk are seriously looking for a job:

$$L^5_k = B\Phi\left[\frac{\tilde{h}^r_{ik}}{\sigma_i\sqrt{1-\rho^2}}, \frac{\tilde{h}^r_{jk}}{\sigma_j\sqrt{1-\rho^2}}\right] \cdot \Phi\left[\frac{\left[U^i_{1k} - U^i_{0k}\right]}{\sigma_{vi}}\right]$$

b) ik is seriously looking for a job, jk is <u>not</u>:

$$L^5_k = B\Phi\left[\frac{\tilde{h}^r_{ik}}{\sigma_i\sqrt{1-\rho^2}}, \frac{-\tilde{h}^r_{jk}}{\sigma_j\sqrt{1-\rho^2}}\right] \cdot \Phi\left[\frac{\left[U^i_{1k} - U^i_{0k}\right]}{\sigma_{vi}}\right]$$

A situation in which ik is <u>not</u> seriously looking for a job doesn't exist

6) $h^{p}_{ik} = 0$, $h^{p}_{jk} = 0$, $unbef_{ik} > 0$, $unbef_{jk} > 0$

a) both ik and jk are seriously looking for a job:

$$L^{6}_{k} = B\Phi\left[\frac{\tilde{h}^{r}_{ik}}{\sigma_{i}\sqrt{1-\rho^{2}}}, \frac{\tilde{h}^{r}_{jk}}{\sigma_{j}\sqrt{1-\rho^{2}}}\right] . \Phi\left[\frac{\left[U^{i}_{1k} - U^{i}_{0k}\right]}{\sigma_{vi}}\right] . \Phi\left[\frac{\left[U^{j}_{1k} - U^{j}_{0k}\right]}{\sigma_{vj}}\right]$$

b) ik is seriously looking for a job, jk is <u>not</u>:

$$L^{6}_{k} = B\Phi\left[\frac{\tilde{h}^{r}_{ik}}{\sigma_{i}\sqrt{1-\rho^{2}}}, \frac{-\tilde{h}^{r}_{jk}}{\sigma_{j}\sqrt{1-\rho^{2}}}\right] . \Phi\left[\frac{\left[U^{i}_{1k} - U^{i}_{0k}\right]}{\sigma_{vi}}\right]$$

$$+ B\Phi\left[\frac{\tilde{h}^{r}_{ik}}{\sigma_{i}\sqrt{1-\rho^{2}}}, \frac{\tilde{h}^{r}_{jk}}{\sigma_{j}\sqrt{1-\rho^{2}}}\right] . \Phi\left[\frac{\left[U^{i}_{1k} - U^{i}_{0k}\right]}{\sigma_{vi}}\right] . \Phi\left[\frac{-\left[U^{j}_{1k} - U^{j}_{0k}\right]}{\sigma_{vj}}\right]$$

Appendix 4. Wage Equations

In our dataset not only actual net wage rates for working individuals are available, but also expected net wage rates for non-working individuals. We assume that for non-working individuals the expected net wage rate is the appropriate variable for the explanation of the labor supply decisions. Thus we estimate for each level of education (log)wage equations for both workers and non-workers together, with the log of family size, the log of age and the squared log of age as explanatory variables. Estimation results are presented in Table A.2.

For purpose of comparison we also estimated wage-equations using data on workers only. We corrected for selection-bias. (Heckman (1979)). In tables A.3 and A.4 the participation-equations and wage equations are presented.

Table A.2: Wage-equations[a),b)]

Log wage-equation for men

level of education	constant	log(age)	$[\log(\text{age})]^2$	number of observations	R^2
1	- 9.34	6.40	- 0.86	290	0.11
	(2.13)	(1.29)	(0.18)		
2	-12.60	8.12	- 1.08	340	0.27
	(2.06)	(1.17)	(0.17)		
3	- 7.72	5.30	- 0.67	656	0.16
	(1.94)	(1.08)	(0.15)		
4	- 6.01	4.27	- 0.52	385	0.16
	(2.75)	(1.53)	(0.21)		

log wage-equation for women

level of education	constant	log(age)	$[\log(\text{age})]^2$	number of observations	R^2
1	- 6.11	4.46	- 0.59	250	0.12
	(2.30)	(1.31)	(0.19)		
2	-10.46	7.04	- 0.96	280	0.18
	(2.28)	(1.31)	(0.19)		
3	- 8.41	5.85	- 0.78	540	0.15
	(1.79)	(1.03)	(0.15)		
4	- 7.98	5.65	- 0.75	194	0.09
	(4.11)	(2.31)	(0.32)		

a) standard errors in parentheses

b) 1 is the lowest level of education

Table A.3: Participation-equations[a)]

	constant	log(age)	$[\log(\text{age})]^2$	number of children younger than 6	log likelihood
men	- 2.1	0.20	- 0.0030		-766
	(0.4)	(0.02)	(0.0002)		
women	1.4	-0.04	- 0.00002	- 0.55	-1169
	(0.3)	(0.02)	(0.0002)	(0.04)	

a) Standard errors in parentheses.

Table A.4: Wage-equations[a,b]

log wage-equation for men

level of education	constant	log(age)	$[\log(age)]^2$	λ_i[c]	R^2	number of observations
1	- 13.87	9.02	- 1.24	0.25	0.12	216
	(6.23)	(3.56)	(0.51)	(0.29)		
2	- 21.05	12.96	- 1.77	0.41	0.29	292
	(5.46)	(3.14)	(0.45)	(0.27)		
3	- 16.34	10.24	- 1.38	0.51	0.20	574
	(5.71)	(3.24)	(0.46)	(0.29)		
4	- 20.20	12.11	- 1.59	0.26	0.26	355
	(7.75)	(4.37)	(0.62)	(0.32)		

log wage-equation for women

level of education	constant	log(age)	$[\log(age)]^2$	λ_i[c]	R^2	number of observations
1	8.21	5.81	- 0.80	0.14	0.12	137
	(3.40)	(1.95)	(0.28)	(0.15)		
2	-18.01	11.50	- 1.62	0.14	0.30	152
	(3.23)	(1.88)	(0.27)	(0.19)		
3	- 8.59	6.00	- 0.82	0.17	0.19	327
	(2.57)	(1.49)	(0.21)	(0.07)		
4	- 7.73	5.74	- 0.81	0.41	0.15	131
	(5.63)	(3.19)	(0.44)	(0.13)		

a) Standard errors in parentheses

b) 1 is the lowest level of education

c) See Heckman (1979)

Appendix 5. Stability

To investigate the stability of the model we write the equations (2.1) - (2.2) and (3.15) - (3.16) in matrix notation:

$$\tilde{h} = \left[\beta \otimes W + I_{2N}\right]\delta + \sum_{j=1}^{7}\left[\gamma_j \otimes x_j\right] + \varepsilon \tag{A.19}$$

$$\delta = \delta_0 \otimes \iota_N + \left[E_1 Z \otimes I_N\right] h(-1) + \left\{\left[E_1\left[I_2 - Z\right] \otimes I_N\right]Q_1 + \right.$$

$$\left. + \left[E_2 \otimes I_N\right]Q_2\right\} h(-1) \tag{A.20}$$

where $h = \left[h_{m1} \ldots h_{mN} h_{f1} \ldots h_{fN}\right]^T$, N := total number of households

$$\tilde{h} = \left[\tilde{h}_{m1} \ldots \tilde{h}_{mN} \tilde{h}_{f1} \ldots \tilde{h}_{fN}\right]^T$$

$$\beta = \begin{bmatrix} \beta_m \\ \beta_f \end{bmatrix}$$

$$W = \begin{bmatrix} w_{m1} & & 0 & w_{f1} & & 0 \\ 0 & \ddots & w_{mN} & 0 & \ddots & w_{fN} \end{bmatrix}$$

$$\delta = \left[\delta_{m1} \ldots \delta_{mN} \delta_{f1} \ldots \delta_{fN}\right]^T$$

$$\gamma_1 = \begin{bmatrix} \gamma_m \\ \alpha \end{bmatrix} \quad \gamma_2 = \tfrac{1}{2}\begin{bmatrix} \beta_m \gamma_m \\ \beta_f \gamma_m \end{bmatrix} \quad \gamma_3 = \begin{bmatrix} \alpha \\ \gamma_f \end{bmatrix} \quad \gamma_4 = \tfrac{1}{2}\begin{bmatrix} \beta_m \gamma_f \\ \beta_f \gamma_f \end{bmatrix}$$

$$\gamma_5 = \begin{bmatrix} \beta_m \alpha \\ \beta_f \alpha \end{bmatrix} \quad \gamma_6 = \begin{bmatrix} \beta_m \\ \beta_f \end{bmatrix} \quad \gamma_7 = \begin{bmatrix} \beta_m \vartheta \\ \beta_f \vartheta \end{bmatrix}$$

$$x_1 = \left[w_{m1} \ldots w_{mN}\right]^T$$

$$x_2 = \left[w_{m1}^2 \ldots w_{mN}^2\right]^T$$

$$x_3 = \left[w_{f1} \ldots w_{fN}\right]^T$$

$$x_4 = \left[w_{f1}^2 \ldots w_{fN}^2\right]^T$$

$$x_5 = \left(w_{m1} w_{f1} \cdots w_{mN} w_{fN}\right)^T$$

$$x_6 = \left(\mu_1 \cdots \mu_N\right)^T$$

$$x_7 = (1 \ \ldots \ 1)^T \triangleq \iota_N^T$$

$$\delta_0 = \begin{pmatrix} \delta_{m0} \\ \delta_{f0} \end{pmatrix}$$

$$E_1 = \begin{pmatrix} \eta_{mm} & 0 \\ 0 & \eta_{ff} \end{pmatrix}; \ E_2 = \begin{pmatrix} \eta_{mf} & 0 \\ 0 & \eta_{fm} \end{pmatrix}$$

$$Z = \begin{pmatrix} \zeta_m & 0 \\ 0 & \zeta_f \end{pmatrix}$$

$$Q^{ii} = \begin{pmatrix} 0 & V_{12}^{ii} & \cdots & V_{1N}^{ii} \\ V_{21}^{ii} & \ddots & & \vdots \\ \vdots & & \ddots & V_{N-1,N}^{ii} \\ V_{N1}^{ii} & \cdots & V_{N,N-1}^{ii} & 0 \end{pmatrix}, \quad Q^{ij} = \begin{pmatrix} V_{11}^{ij} & \cdots & V_{1N}^{ij} \\ \vdots & \ddots & \vdots \\ V_{Ni}^{ij} & \cdots & V_{NN}^{ij} \end{pmatrix}$$

$$Q_1 = \begin{pmatrix} Q^{mm} & 0 \\ 0 & Q^{ff} \end{pmatrix} \qquad Q_2 = \begin{pmatrix} 0 & Q^{mf} \\ Q^{fm} & 0 \end{pmatrix}$$

$i, j = m, f$

I_N := (N by N) identity matrix.

It is assumed that in the long run preferred number of hours, actual number of hours and actual number of hours one period lagged are equal.

Substituting (A.20) into (A.19) then yields

$$h = \left\{I_{2N} - G\left[E_1 Z \otimes I_N + \left[E_1\left(I_2 - Z\right) \otimes I_N\right] Q_1 + \left[E_2 \otimes I_N\right] Q_2\right]\right\}^{-1}$$

$$\left\{G\left[\delta_o \otimes \iota_N\right] + \sum_{i=1}^{7}\left(\gamma_i \otimes x_i\right) + \varepsilon\right\} \tag{A.21}$$

where $G := \beta \otimes W + I_{2N}$.

Define $H := G\left[E_1 Z \otimes I_N + \left[E_1\left(I_2 - Z\right) \otimes I_N\right] Q_1 + \left[E_2 \otimes I_N\right] Q_2\right]$.

Stability of the model is guaranteed when it can be shown that the eigenvalues of H lie within the unit circle. By Gershgorin's Theorem[1)] we are able to specify an upper and lower bound for the eigenvalues.

Gershgorin's Theorem. Each eigenvalue of the K x K matrix

$A = [a_{ij}]$ lies in some interval $I_i = [a_{ii} - \epsilon_i, a_{ii} + \epsilon_i]$,
$i=1,\ldots,K$ where $\epsilon_i = \sum_{j \neq i} a_{ij}$

By applying this theorem to the 2N x 2N matrix H and assuming that each wage rate is less than or equal to 50 (guilders per hour)[2)], we obtain the union of all 2N intervals for the estimated parameters, presented in table 6.4: [0.799, 0.9976]. So the model is shown to be stable.

1) See, e.g., Trenkler (1984)
2) This corresponds to about $ 17.

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